Mobilized Multi-Perspective—Virtual Views

Ingmar S. Franke

Motivation and Contribution

The assumption that three-dimensionality would improve naturalism and intuition within human perceptual processes pushes the optimisation of rendering algorithms of computer graphics. Especially computer graphical visualisation of architecture as a subset of technical pictures suffers from a mathematical and consistent projection, which prevents naturalness as a matter of principal. A Priori, the immobilized view is the key of this problem.

Through the virtual camera, a three-dimensional scene becomes an image. The underlying transformation procedure seems to be based on the tradition of perspective painting since the beginning of Renaissance. While computer graphics ends with the definite determined image, Renaissance painting yet started having a perspective basic structure with defined disturbances.[1]

3D Computer graphics reproduces the Camera Obscura and thereby remains at photo-realism absenting itself from the aim of creating perceptual realistic pictures, not only images. Painters of Renaissance used the Camera Obscura technique far in excess of a pure and singular imaging. They combined different camera views and knowingly composed images as a recording of dynamic perception of their environment.

Between the development of photo and computer graphics, the film is trammelled to the technical limitations of the photo camera. Mostly there is only one point of view—one perspective—within filmic respectively photographic images. Multiperspective, meaning the union of several views in one scene, as used by painters and architectures, is not supported. Images produces this way are mono-perspective.

With the invention of the computer, mathematical models (e.g. central projection) for the creation of images were implemented (e.g. rendering pipeline). These models are based on pure transformation procedures and thereby disregard the multiperspective gaze of human perceptual processes.

However, computers are not bound to the limitations of a photo or movie camera. Computers are able to observe a virtual scene dynamically and transform it into a dialog-oriented picture.

A respective pictorial degree of freedom is being discussed within this article. A new concept of an intuitive virtual camera for applications in spatial visualisations is depicted.

Computer Graphics

To visualise three-dimensional data or models and display them on an end device like a monitor, projections are used within computer graphics. More precisely, most nowadays visualisation systems are using perspective projection to display three-dimensional objects on two-dimensional planes. The transformation is thereby based on geometric rules, which were already discovered or rather developed by the Italian architect Filippo Brunelleschi.

Perspective projection is defined as follows: The centre of projection defines the position of an observer. The projection plane has a certain distance to the observer and defines the image space. The final image results as the set of all intersection points between the projection plane and all projection rays, running from the centre of projection to the three-dimensional data points.[2]

Within computer graphics views into the virtual are described by a virtual camera model. It consists of a centre of projection, the viewing direction and the horizontal field of view. The vertical field of view is defined by the aspect ratio of the projection plane. Hence, all parameters for a perspective projection are fully implemented.

This examination can be specified: The camera parameters define a viewing frustum. The virtual scene is than cut against that frustum determining which region of space will be mapped. For transforming this three-dimensional clipping, the geometry passes through the rendering pipeline (sequence: normalization transformation; clipping; projection; rasterization). These processes are implemented via multiplication of matrices representing single transformations.[3]

Interim conclusion: Until now, computer graphical rendering processes are based on only one single, unchangeable centre of projection. The principal vanishing point of graphical images is always in the centre of the image. The following questions arise from that: How does an image appear, whose principal vanishing point is moving relatively to the image itself? Is this principle similar to the moving gaze of a human observer? Is it possible to integrate several principal vanishing points within one image? How would such an unleashed image look like and appear? The next sections shall clear these questions.

Visual Perception and Painting

The former section illustrated the standard camera model of computer graphics and stated that the centre of projection is a priori unchangeable. It is quasi fixed and immobile. Thereby the resulting principal vanishing point of the image is of essential meaning for its geometric order.[4]

The intersection point of camera's line of vision with the image plane defines the principal vanishing point. In other words, the principal vanishing point is the point of an image where the horizontal line subtends the sagittal line. Using perspective projection leads to increasing distracting linear distortions with increased distance from the principal vanishing point (see fig. 2). These disturbances appear to be extremely unnatural for humans. In the structure of the image, round objects are distorted to elliptic ones, while rectangular objects are widened by rules of perspective projection. Especially, when using Large Projection Displays (e. g. visualisation via beamer) these disturbances are a consciously perceivable defect. The same defect occurs for eccentric partial observers, e. g. a person in a cinema sitting in one of the front rows on the left or right side.

A question arises, how painting encounters this difficulty (see fig. 1) and which concrete pictorial techniques and principles it provides as a solution. Therefore, figure 3 illustrates the problem of the structure of the image of figure 2 geometrically.

An intervention or rather an extension within the computer graphical perspective transformation procedure (rendering pipeline) can avoid distorted images. One possibility is the usage of multiple centres of projection (multiperspective). Thus, the image becomes structured (see fig. 4). From the architectural point of view—a sphere for instance will always be displayed as a circle—such images appear to be more naturally considering the human perception. Within the resulting image, objects turn towards the observer (here the Church Of Our Lady). The dialog between observer and observable items is enhanced (significance of dialog).[5]

An innovation of current computer graphics and Computer Aided Designs (CAD) is taking place, because old methods and techniques for a dialog-oriented structuring of the image against historical and theoretical backgrounds of architectural painting seem to proof useful.

Mobilisation and Multiperspective

Paintings and photos are static. Films and computer graphics open possibilities for dynamic behaviour, like moving image. A moving image is a sequence of images with more than 15 images per second resulting in an illusion of continuity due to human perception.

The following descriptions are simulating the presented multiperspective approach within moving pictures (see Sequence 1). Besides other objects of the image, the Church Of Our Lady has its own centre of projection in this sequence. This centre of projection is object-oriented which means it moves along with the object (in this case the Church Of Our Lady). Thereby the building is always in at the gaze of the observer. For comparison, the right image sequence shows a visualisation made with the standard camera model of computer graphics (see Sequence 2).

Fig. 1: Neumarkt in Dresden, view from Moritzstraße (Canaletto, 1751)

Fig. 2: Computer graphical reproduction of the painting (Groh, 2005)

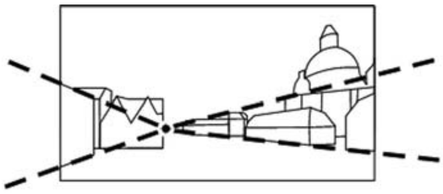


Fig. 3: State of the art—Computer graphics

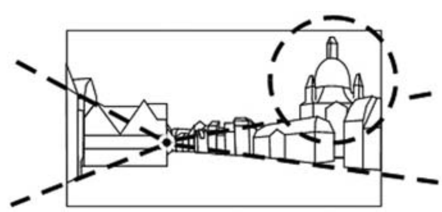


Fig. 4: State of the art—Cognition research

Another comparison of a multiperspective and a monoperspective image show the upper figures 5 and 6. The left figure resulted by using three centres of projection. The image appears to be more natural in its structure and invites for dynamical observation.

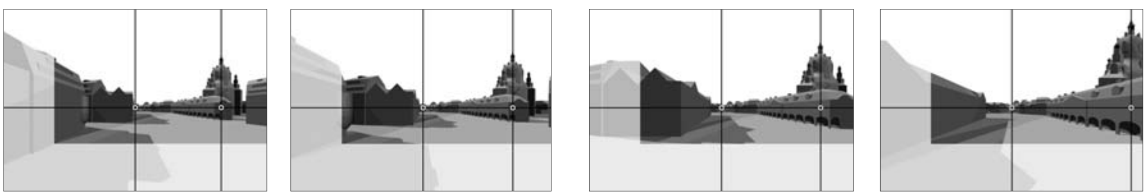
The usage of multiple centres of projection leading to an enhanced dialog between observer and observable items is novel when designing moving pictures using computer graphical systems. Further research should be accomplished.

Conclusion and future work

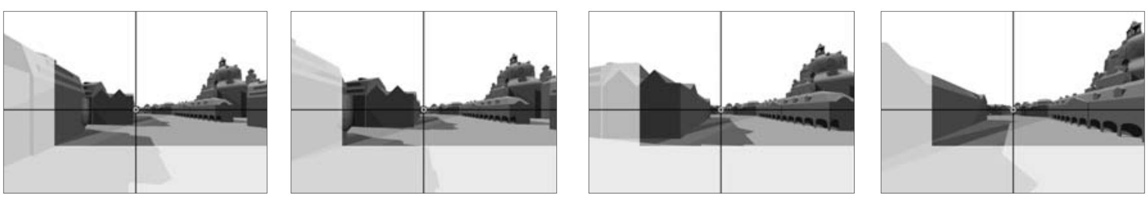
The virtual standard camera model of computer graphics is based on the functions of the Camera Obscura. Similar to this model, the standard camera is able to transform a three-dimensional scene geometrically and definitely into a two-dimensional image. At this state the computer graphics ends, but painters of Renaissance yet began. They used the results of the Camera Obscura and made use of it to compose perceptual pictures. For this purpose the present article identified and discussed a certain degree of freedom, the centre of projection. It multiplied and mobilized it beyond the limitations of the Camera Obscura. The approach of future computer graphics should realign to the visual and cognitive perceptual processes of humans—the key term is perceptual realism.

An evaluation supported by test persons remains. The efficiency of dialog enhancement via the usage of mobilised and multiple centres of projection is currently researched in cooperation with psychologists of engineering and cognitive ergonomics.

Further research is presently concentrated on an eye-tracking supported mobilisation of the centre of projection and the development of a computer graphical working environment for visualisation under real time conditions.



sequence 1: Mobilised multiperspective with two centres of projection/principal vanishing points; one fixed and one moving centre



sequence 2: Monoperspective film with only one centre of projection/principal vanishing point

Fig. 5: Multiperspective image with three centres of projection/principal vanishing points (front and rear buildings and Church Of Our Lady)

Fig. 6: Monoperspective image with only one centre of projection/principal vanishing point

Notes

1 Cf. Arnheim, R., *Die Macht der Mitte – Eine Kompositionslehre für die bildenden Künste*, Köln 1996; Hockney, D., *Secret knowledge – rediscovering the lost techniques of the old masters*, London 2001, and Groh, R., *Das Interaktionsbild – Zu den bildnerischen und theoretischen Grundlagen der Interfacegestaltung*, Dresden 2005.

2 Dürer, A., *Underweysung der messung mit dem zirckel un richtscheyt*, 1525.

3 Cf. Angel, E., *Interactive Computer Graphics, A top-down approach with Open GLTM*, Addison Wesley, Reading, Mass et al., 2000; Encarnaçao, J. L. and Straßer, W., *Gerätetechnik, Programmierung und Anwendung graphischer Systeme*, München and Wien 1988; Rauber, T., *Algorithmen in der Computergraphik*, Stuttgart 1993; Bender, M. and Brill, M., *Computergrafik, Ein anwendungsorientiertes Lehrbuch*, München and Wien 2006; Watt, A., *3D computer graphics*, München 2002.

4 Cf. Arnheim, R., see note 1.

5 Groh, R., see note 1.

Further literature:

Panofsky, E., *Aufsätze zu Grundlagen der Kunstwissenschaften*, Berlin 1985.
Wright, R. S., Lipchak, B., *OpenGL superbible* (Third Edition), Sams Verlag, 2005.